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[Name of Document] Patent Application

[Case No] EB11-425

[To] Commissioner, Patent Office

[International Patent Classification]

H01L 21/02

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[Fees]

[Page No. of Book] 041634

[Amount] ¥21,000.-

[List of the Documents]

[Item] Specification 1

[Item] Drawings 1

[Item] Abstract 1

[General Power of Attorney No.]	9005856
[Proof, requested or not]	requested

[Name of Document] Specification

[Title of the Invention] POLISHING APPARATUS

[Claims]

[Claim 1] A polishing apparatus comprising:

a polishing tool and a substrate holding member to hold a polishing substrate and press a polishing surface of the polishing substrate against the polishing tool, the polishing tool and the substrate holding member being arranged so as to move relative to each other to polish the polishing substrate;

a sensor disposed outside the substrate holding member for sensing a distance between the sensor and the surface of the polishing tool; and

a control unit to determine an occurrence of a polishing failure of the polishing substrate, including a jump thereof from the substrate holding member, on the basis of a variation in the distance measured by the sensor caused by an intervention of the polishing substrate above the surface of the polishing tool.

[Claim 2] A polishing apparatus comprising:

a polishing tool and a substrate holding member to hold the polishing substrate and pressing a polishing surface of the polishing substrate against the polishing tool, the polishing tool and the substrate holding member being arranged so as to move relative to each other to polish the polishing substrate; and

a failure detection sensor to detect a polishing failure of the polishing substrate, including a jump

thereof, disposed within or above the substrate holding member so as to detect such a polishing failure prior to a jump of the polishing substrate from the substrate holding member.

[Claim 3] A polishing apparatus comprising:

a polishing tool and a substrate holding member to hold the polishing substrate and pressing a polishing surface of the polishing substrate against the polishing tool, the polishing tool and the substrate holding member being arranged so as to move relative to each other to polish the polishing substrate;

a condenser composed of electrode plates disposed so as to hold therebetween the both faces of the polishing substrate held by the substrate holding member or of electrode plates disposed at positions at which a polishing substrate jumped out from the substrate holding member is held;

an electric power source for applying a predetermined constant voltage to the condenser; and

an ammeter for measuring a current flowing through the condenser;

whereby a polishing failure on polishing, including a jump of the polishing substrate is detected.

[Claim 4] A polishing apparatus comprising:

a polishing tool and a substrate holding member to hold the polishing substrate and pressing a polishing surface of the polishing substrate against the polishing tool, the polishing tool and the substrate holding member

being arranged so as to move relative to each other to polish the polishing substrate; and

a measuring system allowing a contact member to be in contact with the bottom face of the substrate holding member or with the polishing tool in its surrounding and allowing a current to flow between the contact member and a surface of the polishing tool to measure a current value therebetween, whereby a polishing failure of the polishing substrate, including a jump thereof outside from the substrate holding member is detected on the basis of a variation in the current value caused by passing the polishing substrate between the contact member and the surface of the polishing tool.

[Claim 5] A polishing apparatus comprising:

a polishing tool and a substrate holding member to hold the polishing substrate and pressing a polishing surface of the polishing substrate against the polishing tool, the polishing tool and the substrate holding member being arranged so as to move relative to each other to polish the polishing substrate;

a measuring device for measuring a drive current of a drive unit which drives at least either one of the polishing tool or the substrate holding member; and

a failure detection unit for detecting a polishing failure of the polishing substrate, including a jump thereof outside from the substrate holding member, on the basis of a comparison of the drive current during polishing with a threshold value or a waveform pattern of

the drive current at the time of causing an occurrence of the polishing failure of the polishing substrate.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a polishing apparatus and, more particularly, to a polishing apparatus so adapted as to detect a failure on polishing substrates such as semiconductor wafers or the like including polishing abnormality or jumping out of a substrate during polishing operation.

[0002]

[Conventional Techniques]

In recent years, semiconductor devices become more highly integrated so that circuit interconnections become thinner and that the distances between those interconnections also become smaller. Particularly, for an optical lithography of 0.5 μm or less, the depth of focus becomes so short that a high degree of flatness on the imaging surface of an exposure apparatus is required. Hitherto, a self-flattening CVD apparatus or an etching apparatus has been used as a flattening apparatus for flattening a semiconductor wafer. These apparatuses, however, do not realize a sufficient degree of flatness. Therefore, a polishing apparatus has recently been extensively adopted to flatten a semiconductor wafer because a higher degree of flatness can be expected to be realized readily than the flattening apparatuses as

described immediately above.

[0003]

The polishing apparatus of this type is composed of a turntable and a top ring member, each rotating at a number of rotations discretely and independently from each other, and an abrasive cloth is attached on top of the turntable. Between the turntable and the top ring member is interposed a polishing substrate (e.g., a semiconductor wafer), and the polishing substrate is pressed against the top surface of the turntable at a predetermined pressure. The surface of the polishing substrate is then polished to a predetermined level of flatness and to a mirror surface while a grinding fluid is being fed thereto. After the completion of the polishing process, the polishing substrate is detached from the top ring member and subjected to post-processing processes, including a cleansing process.

[0004]

It is to be noted herein, however, that the polishing substrate may break and broken pieces may scatter on the abrasive cloth during the polishing process. Scratches or damages are given on the surface of a new polishing substrate if the abrasive cloth would be used again. Therefore, a new abrasive cloth has to be used whenever the polishing substrate breaks. On the other hand, even if a polishing substrate would not be broken into pieces, a failure on polishing may be caused to occur, for instance, such that the polishing substrate jumps

outside from the top ring member during the polishing process. If the polishing substrate is a semiconductor silicone wafer or the like made of a brittle material and the polishing substrate would jump outside from the top ring member, the polishing substrate may be damaged or chipped in its outer peripheral portion on account of an impact in a wall surface or the like of the turntable. The damaged polishing substrate is very likely to be broken by application of a slight force onto the damaged portion or at the position close to the damaged portion, when the damaged polishing substrate is polished again.

[0005]

In order to solve the problems as described above, proposals to prevent a failure on polishing, including a breakdown or jump of a polishing substrate outside from the top ring member are devised. For instance, there is proposed a process for reducing an occurrence of breaking or chipping of a polishing substrate upon polishing by using a polishing apparatus with a buffer member such as an elastic mat interposed between the bottom surface of the top ring member and the polishing substrate. Alternatively, there is proposed a process that a jump of a polishing substrate is prevented by fixing the polishing substrate within the top ring member while guiding the outer periphery of the polishing substrate.

[0006]

These proposals, however, are all for the precautionary purposes to prevent a breakdown or jump of

the polishing substrate and useless to deal with the event once the polishing substrate would jump outside from the top ring member. To deal with an event of a polishing substrate jumping from the top ring member, there has hitherto been adopted a process for immediately suspending the polishing operation of the polishing apparatus as a detection system detects a jump of the polishing substrate outside from the top ring member, the detection system being devised to detect the jumping of the polishing substrate from the top ring member and disposed in the vicinity of the outside of the top ring member.

[0007]

This process, however, suffers from the difficulty that the polishing operation cannot be suspended rapidly because the jumping of the polishing substrate can be detected after the polishing substrate has already jumped so that the timing of detection is delayed.

[0008]

Moreover, this process has the problem that a failure upon polishing caused by a breakdown of the polishing substrate cannot be detected. As a result, there is the risk that the polishing of the polishing substrate is continued unless the broken substrate would jump from the top ring member.

[0009]

[Problems to be Solved by the Invention]

Therefore, the present invention has been completed under the situation as described above and has the object

to provide a polishing apparatus that can prevent an occurrence of damages due to a failure on polishing, including a breakdown or a jump of a polishing substrate, by continually managing the polishing operations of the polishing substrate during the polishing process.

[0010]

[Means to Solve the Problems]

In order to achieve the object, the present invention provides a polishing apparatus comprising a polishing tool and a substrate holding member to hold a polishing substrate and press a polishing surface of the polishing substrate against the polishing tool, the polishing tool and the substrate holding member being arranged so as to move relative to each other to polish the polishing substrate; wherein a sensor is disposed outside the substrate holding member for sensing a distance between the sensor and the surface of the polishing tool; and a control unit is disposed to determine an occurrence of a failure on polishing the polishing substrate, including a jump from the substrate holding member, on the basis of a variation in the distance measured by the sensor caused by an intervention of the polishing substrate above the surface of the polishing tool.

The present invention also provides a polishing apparatus comprising a polishing tool and a substrate holding member to hold a polishing substrate and pressing the polishing surface of the polishing substrate against

the polishing tool, the polishing tool and the substrate holding member being arranged so as to move relative to each other to polish the polishing substrate; wherein a failure detection sensor to detect a polishing failure on polishing the polishing substrate, including a jump of the polishing substrate, is disposed within or above the substrate holding member so as to detect such a polishing failure prior to a jump of the polishing substrate from the substrate holding member.

In the present invention, the failure detection sensor may include a supersonic sensor, a displacement sensor, a piezoelectric element, a distortion sensor or a vibration sensor.

The present invention further provides a polishing apparatus comprising a polishing tool and a substrate holding member to hold a polishing substrate and pressing a polishing surface of the polishing substrate against the polishing tool, the polishing tool and the substrate holding member being arranged so as to move relative to each other to polish the polishing substrate; wherein a condenser is composed of electrode plates disposed so as to hold therebetween the both faces of the polishing substrate held by the substrate holding member or electrode plates disposed at positions at which to hold the polishing substrate jumped outside the substrate holding member; an electric power is disposed to apply a predetermined constant voltage to the condenser; and an ammeter is disposed to measure a current passing through

the condenser; whereby a polishing failure upon polishing, including a jump of the polishing substrate, is detected.

The present invention further provides a polishing apparatus comprising a polishing tool and a substrate holding member to hold a polishing substrate and pressing the polishing surface of the polishing substrate against the polishing tool, the polishing tool and the substrate holding member being arranged so as to move relative to each other to polish the polishing substrate; wherein a contact member is disposed in contact with the bottom face of the substrate holding member or with the polishing tool in its surrounding; and a measuring system is disposed to allow a current to flow between the contact member and the surface of the polishing tool and to measure a current value therebetween; whereby a failure on polishing, including a jump of the polishing substrate outside from the substrate holding member, is detected on the basis of a variation in the current value caused by the polishing substrate passing between the contact member and the surface of the polishing tool.

The present invention further provides a polishing apparatus comprising a polishing tool and a substrate holding member to hold a polishing substrate and pressing a polishing surface of the polishing substrate against the polishing tool, the polishing tool and the substrate holding member being arranged so as to move relative to each other to polish the polishing substrate; wherein a measuring device is disposed to measure a drive current of

a drive unit for driving at least either one of the polishing tool or the substrate holding member; and a failure detection unit is disposed to detect a polishing failure on polishing the polishing substrate, including a jump of the polishing substrate outside from the substrate holding member, on the basis of a comparison of the drive current during polishing with a threshold value or a waveform pattern of the drive current at the time of causing the polishing failure.

[0011]

[Embodiments of the Invention]

The present invention will be described in more detail by taking as an example a chemical-mechanical polishing apparatus (a CMP apparatus) with a cleansing device for use in the present invention.

[0012]

Fig. 13 is a schematic view showing an entire outline of an example of the polishing apparatus of this type. As shown in Fig. 13, the polishing apparatus includes a polishing machine 110 and a cleansing device 126. The polishing machine 110 may comprise two polishing machines 110a and 110b disposed symmetrically on the left-hand and right-hand sides. The cleansing device 126 is composed of two primary cleansing devices 126a1 and 126a2 as well as two secondary cleansing devices 126b1 and 126b2. The cleansing devices 126a1 and 126b1 are disposed on the side of the polishing machine 110a and the cleansing devices 126a2 and 126b2 are disposed on the side of the

polishing machine 110b. A group of the cleansing devices 126a1 and 126b1 is located symmetrically with another group of the cleansing devices 126a2 and 126b2. Further, two reversing devices 128a and 128b are likewise disposed symmetrically with each other so as to correspond with the polishing machines 110a and 110b, respectively. Likewise, two transport machines 124a and 124b and two load-unload portions 122 are disposed symmetrically with each other.

[0013]

The polishing machine 110a is composed of a polishing table 2a and a top ring 4a for polishing a semiconductor wafer held on its bottom surface by pressing it against the polishing table 2a. Likewise, the polishing machine 110b is composed of a polishing table 2b and a top ring 4b for polishing a semiconductor wafer held on its bottom surface by pressing it against the polishing table 2b.

[0014]

For the polishing apparatus having the configuration as described above, a semiconductor wafer is transferred from the load-unload portion 122 through the transport machines 124a and 124b to a delivery device 138a. The semiconductor wafer is then adsorbed on the bottom surface of the top ring 4a by means of the delivery device 138a and then transferred onto the polishing table 2a. Likewise, another semiconductor wafer transferred from the load-unload portion 122 onto a delivery device 138b is adsorbed on the bottom surface of the top ring 4b and then

transferred onto the polishing table 2b. On the top surfaces of the polishing tables 2a and 2b are mounted polishing tools 1a and 1b, respectively, each having a grinding face on its top surface and including a grinding pad, rubstone or any other appropriate means. The semiconductor wafer is polished or ground by pressing it against the grinding face of the polishing tool while feeding a grinding fluid (e.g., a grinding material having a predetermined particle size being suspended in an alkali aqueous solution in the event where an insulating membrane (an oxide membrane) coated on a Si wafer is to be polished) and rotating the polishing table 2a or 2b and the top ring 4a or 4b. After the polishing has been finished, the semiconductor wafer polished is returned to the load-unload portion 122 via the cleansing-drying process.

[0015]

Each of the primary cleansing devices 126a1 and 126a2 is a cleansing machine of a low-speed rotary type that can rotate a wafer at a low speed by the rotation of a plurality of upright rollers 130 disposed so as to enclose the wafer. The wafer is held at its outer peripheral edge portion through grooves formed at the upper outer peripheries of the rollers 130. Further, a cleansing member composed of a sponge of a roller type or of a pencil type or any other appropriate member is disposed so as to come into contact with the wafer each from top and bottom and evacuate therefrom. The secondary

cleansing devices 126b1 and 126b2 are each a cleansing machine of a high-speed rotary type that can rotate the wafer at a high speed, extending an arm in a radial direction, the arm clamping the wafer at the top end of a rotary shaft.

[0016]

After the polishing process was completed, the cleansing process is carried out in a manner as will be described hereinafter. The cleansing process involves, first, cleansing by scrubbing a wafer with a cleansing member while feeding a cleansing fluid to the top and bottom surfaces of the wafer and rotating the wafer by the primary cleansing device 126a1 or 126a2.

[0017]

Then, the wafer is cleansed by the secondary cleansing device 126b1 or 126b2 and dried while rotating it at a high speed. After the cleansing process and the drying process were completed, then the wafer is returned to the load-unload portion 122 by means of a clean hand of the transport machine 124b.

[0018]

The polishing apparatus according to the present invention can adopt a parallel operation method and a straight operation method. In the present invention, the parallel operation method is arranged so as to comprise polishing two sheets of wafers discretely by the polishing machines 110a and 110b, respectively, and the straight operation method is arranged so as to comprise

transferring one sheet of wafer to the polishing machine 110a and then to the polishing machine 110b and polishing it discretely by each of the polishing machines 110a and 110b.

[0019]

The parallel operation method uses each of the polishing machines 110a and 110b for subjecting a polishing substrate to normal polishing using a polishing or grinding material and to finish polishing. This method can carry out the water-polishing step without using any polishing or grinding material at different timings, thereby enabling transferring the semiconductor wafers effectively by the transport machines 124a and 124b. The polishing apparatus for use in this invention includes the polishing machines 110a and 110b, the primary cleansing devices 126a1 or 126a2, as well as the secondary cleansing device 126b1 or 126b2 in the manner as described above. Therefore, two wafer-processing lines can be provided, a first wafer-processing line comprising a polishing step by the polishing machine 110a, a primary cleansing step by the primary cleansing device 126a1, and a secondary cleansing step by the secondary cleansing device 126b1 and a second wafer-processing line comprising a polishing step by the polishing machine 110b, a primary cleansing step by the primary cleansing device 126a2, and a secondary cleansing step by the secondary cleansing device 126b2. This system allows two transport lines for transferring semiconductor wafers to be operated discretely from each

other and in a parallel fashion without causing one transport machine to interfere with the operation of the other transport machine. Therefore, this system remarkably improves efficiency of the polishing operation of the polishing apparatus.

[0020]

On the other hand, the straight operation method involves conducting the normal polishing step for polishing a semiconductor wafer with the polishing machine 110a and the water-polishing step for polishing the semiconductor wafer transferred to the other polishing machine 110b from the polishing machine 110a. If contamination on the polishing machine does not cause any problem, the semiconductor wafer may be transferred from the one polishing machine 110a to the other polishing machine 110b by the transport machine 124a. On the other hand, if the problem with contamination has to be taken into account, the semiconductor wafer is first subjected to the normal polishing step with the polishing machine 110a and then to the water-polishing step with the polishing machine 110b after the semiconductor wafer was transferred through the transport machine 124a to the primary cleansing device 126a1 and subjected to the primary cleansing process. The cleansing process with the primary cleansing device 126a1 may be carried out by using an appropriate cleansing agent in accordance with the kind of slurry used for the one polishing machine 110a. For the straight operation method for use in this invention,

the normal polishing step and the water-polishing step are carried out discretely by the polishing tables 2a and 2b, respectively, so that a grinding fluid and purified water on the polishing tables are not required to be exchanged whenever the polishing steps are conducted. This system can shorten the time required for the polishing process and save amounts of the grinding fluid and purified water.

[0021]

For the polishing apparatus according to the present invention, each of the polishing machines 110 (110a and 110b) is provided with a failure detection system that can detect an occurrence of a polishing failure upon polishing a semiconductor wafer (a polishing substrate) to be polished.

[0022]

[FIRST EMBODIMENT] … Detection of a failure by a supersonic sensor

Fig. 1 is a schematic front view of the polishing table (turntable) 2 and the top ring 4 disposed in the polishing machine 110 and Fig. 2 is a schematic side view of the polishing table 2 and the top ring 4 when looked from the arrow A in Fig. 1.

[0023]

As shown in Figs. 1 and 2, the polishing table 2 is of a disk shape having a rotary table shaft 3 for rotating the polishing table 2 disposed at the center on the bottom surface thereof. On the top surface of the polishing table 2 is mounted the polishing tool 1 composed of a

grinding pad, rubstone or the like.

[0024]

The top ring 4 has a rotary top-ring shaft 5 for rotating the top ring disposed at the center on the top surface thereof. A top portion of the rotary top-ring shaft 5 is inserted into a turn arm 6 for the top ring disposed so as to be drivable and rotatable by a drive unit disposed within the turn arm 6 that in turn is turned by a rotary turn-arm shaft 7. More specifically, the top ring 4 is configured so as to be movable between the delivery tool 138 (a or b)(Fig. 13) and the polishing table 2 (a or b), respectively. A grinding fluid supply tube 50 for feeding a grinding fluid (slurry) S is also disposed at the top portion of the polishing table 2.

[0025]

In the present invention, a supersonic sensor (a failure detection sensor) 10 is disposed in the vicinity of the side of the top ring 4. The supersonic sensor 10 is mounted on a sidewall of the turn arm 6 through an arm 51. The supersonic sensor 10 is composed of a supersonic wave transmitting section 10a and a supersonic wave receiving section 10b and disposed therein. The supersonic sensor 10 can compute a distance between the sensor and the surface of a semiconductor wafer by detecting the time required for the supersonic wave emitted from the supersonic wave transmitting section 10a to reach the supersonic wave receiving section 10b.

[0026]

Fig. 3 shows a control block diagram for the supersonic sensor 10. As shown in Fig. 3, signals outputted from the supersonic sensor 10 are inputted to a control unit 43 and outputted therefrom to a motor control section 45 for controlling a motor for driving the turntable and to a motor control section 46 for controlling a motor for driving the top ring. In response to the signals from the control unit 43, the motor control section 45 controls the driving of the rotation of the polishing table 2 and the motor control section 46 controls the driving of the rotation of the top ring 4.

[0027]

Fig. 4 is a flowchart showing an example of the procedure for the detection of a failure on polishing a semiconductor wafer W by means of the supersonic sensor 10 during the polishing process. The semiconductor wafer W held on the bottom face of the top ring 4 is subjected to polishing or grinding the polishing surface of the wafer W in contact with the polishing or grinding surface of the polishing tool 1 by rotating the top ring 4 relatively to the polishing table 2. During the polishing of the wafer W, a distance L between the supersonic sensor 10 and a polishing or grinding surface (a fluid surface of a grinding fluid) of the polishing tool 1 is measured at a predetermined sampling cycle (100 msec for example) by the supersonic sensor 10 (step 1).

[0028]

More specifically, a time T (a time required for a

supersonic pulse transmitted from the supersonic sensor to the grinding surface of the polishing tool 1 and to return to the sensor after reflection on the grinding surface thereof) is measured and the distance L is computed by the control unit 43 shown in Fig. 3 on the basis of the following equation:

$$L = V \times T \div 2$$

$$V = f \times \lambda$$

where: V = speed of sound within a supersonic wave propagating medium (air in this embodiment);

f = frequency of a piezoelectric transducer of the supersonic wave transmitting section 10a; and

λ = wavelength of the supersonic wave transmitted.

It is noted herein that Fig. 1 illustrates the transmitting and reflecting waves each having incident and outgoing angles, respectively, for brevity of illustration, although the waves enter and reflect at substantially right angles in an actual situation.

[0029]

Now, a description will be given regarding an example of the computation of the distance L between the supersonic sensor 10 and the grinding surface of the polishing tool 1 under the conditions that a plate thickness of the semiconductor wafer W is 1 mm and the wavelength λ of the supersonic wave to be transmitted is 0.1 mm. The above equation gives the frequency f of the piezoelectric transducer of the supersonic wave transmitting section 10a as f = 340 (m/s)/0.1 (mm) = 3.40

(MHz). Therefore, the piezoelectric transducer composed of a piezoelectric element or the like, having this frequency f as natural frequency can be used as a source for transmitting supersonic waves. In this case, when the time T is set to T = 0.59 msec, the distance L is measured as L = 10 cm from the above equation.

[0030]

Then, the control unit 43 compares the measured distance L with a threshold value L1 pre-stored in the control unit 43. As the result of comparison gives L ˜ L1, this result is determined as normal (step 2) and the polishing operation is continued (step 3). On the other hand, as the result of comparison gives L < L1, it is then determined that the distance between the supersonic sensor 10 and the polishing substrate located thereunder becomes shorter than normal and that a foreign material is present on the way between the supersonic sensor 10 and the top surface of the polishing tool 1, that is, for example, the semiconductor wafer W jumped from the top ring 4 or a broken piece of the semiconductor wafer is present. Therefore, in this event, it is determined that there is a failure on polishing (step 2), and then the driving of the turntable 2 and the top ring 4 is suspended (step 4).

[0031]

It is to be noted herein that the threshold value L1 is set as a value computed by statistically processing values obtained by measuring the distance between the sensor and the polishing surface of the semiconductor

wafer W several times while the semiconductor wafer W is polished under actual polishing conditions in such a state that the wafer W is held normally with the top ring 4.

[0032]

At step 4, the driving of the turntable 2 and the top ring 4 is suspended by sending braking signals from the control unit 43 to the motor control section 45 for controlling the rotation of the motor for driving the turntable and to the motor control section 46 for controlling the rotation of the motor for driving the top ring and suspending the driving of the motors in response to the braking signals. In this embodiment, an example is described wherein the drive motors are braked to suspend the driving of the turntable 2 and the top ring 4. It is to be noted herein, however, that in place of or in addition to the above embodiment, a so-called mechanical brake may also be used which may be configured, for instance, such that a brake drum is disposed on a rotary section of the turntable 2 and the turntable 2 is braked by pressing a brake shoe against the brake drum. Moreover, the driving of the top ring 4 may be suspended simply by turning power off because the inertia force of the top ring 4 is small.

[0033]

[SECOND EMBODIMENT] … Detection of a failure by a supersonic sensor

Fig. 5 is a schematic front view of the polishing table (turntable) 2 and the top ring 4. In Fig. 5, the

parts and elements identical or similar to the parts and elements of the polishing apparatus according to the first embodiment of the present invention are provided with the identical reference numerals and symbols and a description of the same parts and elements will be omitted from the following explanation. In the second embodiment of the polishing apparatus, two supersonic sensors (failure detection sensors) 10-1 and 10-2 are mounted on the top surface of the top ring 4. The supersonic sensor 10-1 is disposed on top of a guide ring 4-1 holding an outer periphery of a semiconductor wafer W, and the supersonic sensor 10-2 is disposed at the position inside of the guide ring 4-1. Passages 4-4 and 4-5 extending vertically through the entire thickness of the top ring 4 from the respective supersonic sensors 10-1 and 10-2 are formed at the respective positions at which the supersonic sensors 10-1 and 10-2 are disposed.

[0034]

Each of the supersonic sensors 10-1 and 10-2 emits supersonic waves through the respective passages 4-4 and 4-5 toward an object and receives the supersonic waves reflected at the object and returned therefrom, in order to measure an intensity of reflection (a sound pressure). A failure on polishing the semiconductor wafer W can be detected on the basis of a variation in the intensity of reflection. Further, in this embodiment, it can be noted that the supersonic frequency of the supersonic waves oscillated by the supersonic sensors 10-1 and 10-2 is set

so as to become the frequency corresponding to the resonance frequency of the semiconductor wafer W itself.

[0035]

Fig. 6 is a control block diagram for the supersonic sensors 10-1 and 10-2. As shown in Fig. 6, the signals detected by the supersonic sensors 10-1 and 10-2 are entered into the control unit 43, and the control unit 43 outputs signals for controlling the motor to the motor control section 45 for controlling the motor for driving the turntable and to the motor control section 46 for controlling the motor for driving the top ring. In this embodiment having the configuration as described above, a failure on polishing the semiconductor wafer W may be detected in the following procedures.

[0036]

First, rotating the top ring 4 and the turntable 2 in contact with the grinding surface of the polishing tool 1 polishes the polishing surface of a semiconductor wafer W held on the bottom face of the top ring 4. During this polishing process, the supersonic sensors 10-1 and 10-2 emit supersonic waves continually onto the grinding surface of the polishing tool 1 and the polishing surface of the semiconductor wafer W, and the supersonic waves reflected from the wafer W are receiving by the respective supersonic wave receiving sections of the supersonic sensors 10-1 and 10-2. Upon receiving the reflected waves, sound pressure levels Z1 and Z2 are measured, respectively, from the sound pressure p. The relationship of the sound

pressure level Z (dB) with the sound pressure p (μPa) can be indicated by the following equation:

$$Z = 10 \log_{10}(p/20).$$

[0037]

At this time, the semiconductor wafer W is caused to vibrate by the resonance with the supersonic waves transmitted by the supersonic sensor 10-2, so that the sound pressure level Z2 measured by the supersonic sensor 10-2 is lowered. On the other hand, the supersonic waves transmitted by the supersonic sensor 10-1 onto the polishing tool 1 are reflected at the grinding surface thereof so that no resonance is caused and a predetermined sound pressure level Z1 is to be measured.

[0038]

If the semiconductor wafer W jumps or deviates outside from the predetermined position of the top ring 4 as shown in Fig. 5, the supersonic waves transmitted from the supersonic sensor 10-2 are reflected on the surface of the polishing tool 1 so that no resonance is caused with the semiconductor wafer W and the sound pressure level Z2 becomes larger. On the other hand, the supersonic waves transmitted from the supersonic sensor 10-1 are reflected by the semiconductor wafer W moving underneath the sensor so that the sound pressure level Z1 is lowered by resonance with the semiconductor wafer W. Further, for instance, in the event where the semiconductor wafer W would be broken in the top ring 4, the resonance frequency of the broken wafer is changed so that the sound pressure

level Z2 to be measured by the supersonic sensor 10-2 becomes larger.

[0039]

Then, as shown in Fig. 6, the control unit 43 determines a change of the sound pressure level as an occurrence of a failure on polishing the semiconductor wafer W if at least either one of the sound pressure levels Z1 and Z2 is changed from the respective threshold values Z01 and Z02. At this time, controlling the motor control section 45 and the motor control section 46 suspends the driving of the turntable 2 and the top ring 4 in substantially the same manner as in the first embodiment.

[0040]

The threshold values Z01 and Z02 are determined in advance by measuring the sound pressure levels Z1 and Z2 several times while the polishing is effected under actual conditions in a state in which the semiconductor wafer W is normally held by the top ring 4 and then by statistically processing the measured sound pressure levels.

[0041]

When the supersonic sensors 10-1 and 10-2 are disposed above the top ring 4 in the manner as in the embodiment, a failure on polishing can be detected prior to the jumping of the wafer W from the top ring 4 so that this embodiment enables detecting a failure on polishing faster than the detection process in the first embodiment

wherein a jump of the semiconductor wafer W is detected after it has already been jumped therefrom.

[0042]

[VARIANT OF SECOND EMBODIMENT] … Detection of a failure by a supersonic sensor

In the second embodiment of the present invention, the supersonic frequency of the supersonic waves oscillated by the supersonic sensors 10-1 and 10-2 is set as the frequency corresponding to the resonance frequency of the semiconductor wafer W itself. In this embodiment, however, it is set as a frequency other than that frequency. In this case, a failure on polishing the semiconductor wafer W can be detected on the basis of a variation in the intensity of reflection (sound pressure level) measured simply from the object without using the damping of the intensity of the reflected waves by the resonance of the semiconductor wafer W.

[0043]

More specifically, each of the supersonic sensors 10-1 and 10-2 transmits supersonic waves to an object and receives the waves reflected from the object through the passages 4-4 and 4-5, respectively, so that an intensity of reflection (sound pressure levels Z1 and Z2) of the supersonic waves is measured. If it is found that the sound pressure level Z1 (Z2) does not satisfy the relationship as indicated by $Zs1 < Z1 < Zh1$ ($Zs2 < Z2 < Zh2$), then the control unit 43 determines that there is a failure on polishing the semiconductor wafer W. Then, the

driving of the turntable 2 and the top ring 4 is suspended in substantially the same manner as in each of the previous embodiments.

[0044]

In these procedures, a width of the threshold values is set to be Zs1 and Zs2 for the lower sound pressure levels as well as Zh1 and Zh2 for the higher sound pressure level by measuring the sound pressure levels Z1 and Z2 several times, respectively, while the polishing is effected under actual polishing conditions in a state in which the semiconductor wafer W is held normally by the top ring 4.

[0045]

[VARIANTS OF FIRST AND SECOND EMBODIMENTS] … Detection of a failure by a radiation temperature sensor

In the first and second embodiments, the supersonic sensors 10, 10-1 and 10-2 are used. In the respective variant embodiments, radiation temperature sensors are used in place of the supersonic sensors 10, 10-1 and 10-2, respectively, at the positions at which the supersonic sensors 10, 10-1 and 10-2 were disposed in the first and second embodiments. In this embodiment, the temperature of a measuring object (the surface of the semiconductor wafer W or the polishing tool 1) is continually measured by the radiation temperature sensors during polishing. By continually measuring the temperature of the measuring object, the control unit 43 can detect a failure on polishing the object, including a breakdown or jump from a

predetermined position, as the measured temperature exceeds a predetermined threshold value (temperature) at which such a polishing failure is caused to occur. Once such a failure is detected, the driving of the turntable 2 and the top ring 4 is suspended in substantially the same manner as in each of the previous embodiments.

[0046]

[THIRD EMBODIMENT] … Detection of failure based on a variation in electrostatic capacity of a condenser

Fig. 7 is a schematic front view of the polishing table (turntable) 2 and the top ring 4 according to the third embodiment of the present invention. In Fig. 7, the parts and elements identical and similar to those of the first embodiment are provided with the same reference numerals and symbols as those of the first embodiment, and a description of those parts and elements will be omitted in the following specification for brevity of explanation. In this embodiment, a circular negative-electrode plate 11-1 having substantially the same diameter as a semiconductor wafer W is mounted on the bottom face of the top ring 4 through a backing member 4-6. A circular negative-electrode plate 12-1 is mounted on a forward end of a conductive support bar 17 at a position close to the outer periphery of the top ring 4. On the other hand, a ring-shaped positive-electrode plate 11-2 is embedded in the turntable 2 at the opposite position of the circular negative-electrode plate 11-1. Likewise, a ring-shaped positive-electrode plate 12-2 is embedded in the turntable

2 at the opposite position of the circular negative-electrode plate 12-1. In other words, the ring-shaped positive-electrode plates 11-2 and 12-2 as well as the circular negative-electrode plates 11-1 and 12-1 constitute condensers such that the ring-shaped positive-electrode plates 11-2 and 12-2 are located in parallel to the circular negative-electrode plates 11-1 and 12-1, respectively, in whichever direction the turntable 2 is rotated. The circular negative-electrode plate 12-1 is disposed above the polishing tool 1 in a predetermined spaced relationship so as to allow the semiconductor wafer W jumped from the top ring 4 to pass through a clearance between the circular negative-electrode plate 12-1 and the ring-shaped positive-electrode plate 12-2.

[0047]

Each of the circular negative-electrode plates 11-1 and 12-1 is grounded, and voltage sources V1 and V2 are connected to the ring-shaped positive-electrode plates 11-2 and 12-2, respectively, so as to apply a predetermined constant voltage to each condenser. Further, ammeters A1 and A2 for measuring currents flowing through the condensers are connected to the respective ring-shaped positive-electrode plates 11-2 and 12-2. Reference numerals 16-1 and 16-2 each denote a slip ring.

[0048]

In this embodiment, the semiconductor wafer W is held by the top ring 4 and polished in substantially the same manner as in the first embodiment. On the other hand,

the condenser has an electrical amount $Q = C \times V$ (in which Q is an electrical amount accumulated between condenser electrode plates; C is an electrostatic capacity; and v is a voltage differential between electrode plates). When the voltage differential V is set to be constant, the differentiation of the electrical amount with the time t gives $dQ/dt = I = dC/dt \times V$ (in which I is an electric current). Therefore, the electric current flows as the electrostatic capacity C varies.

[0049]

During the polishing of the semiconductor wafer W, the current value of each condenser is continually measured by the respective ammeters A1 and A2. The output of the current values measured by the ammeters A1 and A2 is sent to a control unit (not shown) through a rotary joint (not shown).

[0050]

As each of the condenser capacities does not vary during the normal polishing process, no current is applied to the ammeters A1 and A2.

[0051]

On the other hand, however, in the event where a semiconductor wafer W would break or jump outside from the top ring, the electrostatic capacity of the condenser composed of the circular negative-electrode plate 11-1 and the ring-shaped positive-electrode plate 11-2 changes. Further, the electrostatic capacity of the condenser composed of the circular negative-electrode plate 12-1 and

the ring-shaped positive-electrode plate 12-2 changes in the event where the semiconductor wafer W jumped therefrom passes through the condenser.

[0052]

Therefore, it is determined in this embodiment that a failure on polishing occurs in the event where either of the current values measured by the ammeters A1 and A2 exceeds a predetermined threshold value as a result of comparison. The threshold value is previously obtained by subjecting the current values to simulation several times, which cause a failure on polishing, for instance, on account of a breakdown or a jump of the polishing substrate W. Alternatively, it is likewise determined as an occurrence of a failure on polishing of the semiconductor wafer W in the event where either one of waveform patterns of a periodical variation of each value measured by the respective ammeters A1 and A2 in a predetermined sampling time agrees with a preset waveform pattern of a periodical variation of the current value at which a failure is caused to occur, for instance, by a breakdown or jumping of the semiconductor wafer W from the top ring. The waveform pattern to be preset may be obtained by subjecting a waveform pattern indicative of a periodical variation in the current values to several simulations, at which such a polishing failure is caused to occur. As it is determined that polishing failure has occurred, then the driving of the turntable 2 and the top ring 4 is suspended in substantially the same manner as in

the above first embodiment.

[0053]

In this embodiment, the condenser is disposed inside and outside the top ring 4 such that a failure on the polishing of the semiconductor wafer W is detected. Alternatively, the condenser may be disposed at one location or a plurality of electrode plates on the side of the top ring may be disposed for the ring-shaped electrode plate on the side of the turntable. The polarity of each of the negative-electrode plates 11-1 and 12-1 and each of the positive-electrode plates 11-2 and 12-2 may be reversed.

[0054]

The condenser (in this embodiment, composed of the circular negative-electrode plate 12-1 and the ring-shaped positive-electrode plate 12-2) to be disposed outside the top ring 4 may be disposed at the predetermined position by in advance determining the position at which a semiconductor wafer W is most likely to jump or deviate from the top ring by means of simulation.

[0055]

With the configuration as described above, a failure on polishing can be detected prior to the jumping of the semiconductor wafer W outside from the top ring 4 by locating the condenser inside the top ring 4 as in this embodiment. This system has the advantage that a polishing failure can be detected faster than the process of detecting the semiconductor wafer W after the wafer W

has jumped outside from the top ring 4 as in the first embodiment.

[0056]

[FOURTH EMBODIMENT] … Detection of a failure based on a variation in current values

Fig. 8 depicts a portion of the polishing table (turntable) 2 and the top ring 4 according to the fourth embodiment of the present invention, in which Fig. 8(a) is a schematic plan view and Fig. 8(b) is a schematic front view. In this embodiment, the same or similar parts and elements are provided with the same reference numerals and symbols as those of the first embodiment, and a description of those parts and elements will be omitted from the following specification for brevity of explanation. In this embodiment, a ring-shaped contact member 21 is disposed at the outer periphery of the guide ring 4-1 on the bottom face of the top ring 4 so as to be in abutment with the surface of the polishing tool 1. On the other hand, a ring-shaped conductive member 20 is disposed at the outer periphery of the polishing tool 1, and a conductive contact member 22-2 supported by a conductive member 23-2 is located in abutment with the surface of the ring-shaped conductive member 20. Further, a conductive contact member 22-1 supported by a conductive member 23-1 is located in abutment with the surface of the polishing tool 1 outside the top ring 4. The position of the conductive member 23-1 is located at the position at which a semiconductor wafer W jumps, i.e., the position

downstream of the top ring 4 for the turntable 2.

[0057]

The ring-shaped conductive member 20 is grounded, and voltages V1, V2 and V3 are applied to the conductive contact member 22-2, the ring-shaped contact member 21 and the conductive contact member 22-1, respectively. Further, ammeters A1, A2 and A3 are connected to the conductive contact member 22-2, the ring-shaped contact member 21 and the conductive contact member 22-1, respectively.

[0058]

During the polishing process of the semiconductor wafer W, the polishing tool 1 is electrically connected to the ring-shaped contact member 21 and to the conductive contact member 22-1, and the ring-shaped conductive member 20 is electrically connected to the conductive contact member 22-2. The current values for the connections are continually measured by the ammeters A1, A2 and A3, respectively. As acidic or alkaline slurry is supplied to the polishing tool 1, the electrical connections of each of the contact members with the polishing tool 1 can be performed through the slurry supplied thereto and the ring-shaped conductive member 20 because the polishing tool 1 composed of a polishing member including an abrasive cloth or rubstone is generally high in insulation. The polishing tool 1 may be of a material containing a conductive material. The polishing tool 1 may be completely substituted for the ring-shaped conductive member 20.

[0059]

If a failure on polishing would occur in the event, for instance, where a semiconductor wafer W jumps outside from the top ring 4 or it breaks, the current values measured by the ammeters A1, A2 and A3 change because the electric connections change due to the crossing of the semiconductor wafer W having highly electrical resistance through each of the contact members 21, 22-1 and 22-2 as well as the polishing tool 1.

[0060]

Therefore, it is determined by a control unit (not shown) that a failure on polishing the semiconductor wafer W occurs, for instance, due to the jumping or breaking of the semiconductor wafer W, in the event where either one of the current values measured by the ammeters A1, A2 and A3 exceeds a predetermined threshold value as a result of comparison. The threshold value is in advance obtained by subjecting the current values to several simulations, at which such a polishing failure is caused to occur. Alternatively, it is determined that such a failure on polishing of the semiconductor wafer W occurs in the event where either one of a waveform pattern of a periodical variation of each value measured by the respective ammeters A1, A2 and A3 in a predetermined sampling time agrees with preset waveform patterns W1, W2 and W3, respectively. The waveform patterns W1, W2 and W3 are obtained by subjecting waveform patterns of a periodical variation in the current values to several simulations

under conditions that such a polishing failure is caused to occur, for instance, due to jumping or breaking of the semiconductor wafer W. As it is determined that a polishing failure has occurred, then the driving of the turntable 2 and the top ring 4 is suspended in substantially the same manner as in the above first embodiment.

[0061]

In this embodiment, a polishing failure occurring in the event of the jumping or breaking of the semiconductor wafer W is detected on the basis of a variation in the current values in the vicinity of the guide ring 4-1 and outside the top ring 4. In this embodiment, however, such a failure may be detected by measuring the current value at either one location.

[0062]

[FIFTH EMBODIMENT] … Detection of a failure due to a variation in contact pressure of a piezoelectric element

Fig. 9 illustrates the polishing table (turntable) 2 and the top ring 4 for use in accordance with the fifth embodiment. In Fig. 9, (a) is a schematic plan view of the polishing table (turntable) 2 and the top ring 4 and (b) is a schematic front view of the polishing table 2 and the top ring 4 (taken along the line Y2-Y2). The same or similar parts and elements are provided with the same reference numerals and symbols as those of the first embodiment, and a description of those parts and elements will be omitted from the following explanation.

[0063]

In this embodiment, a spacer 28 is mounted at the bottom surface of the top ring 4. The spacer 28 is provided with groups of bores, each group consisting of three bores arranged in a radial direction. A piezoelectric element 24 is disposed in each of the bores. Further, four piezoelectric elements 25 are equally mounted on the bottom surface of a guide ring 4-1. Moreover, piezoelectric elements 26-1 and 26-2 are disposed on the surface of the polishing tool 1 at predetermined positions outside the top ring 4 and supported by support members 27-1 and 27-2, respectively. In order to compare the current values measured by the piezoelectric elements 24, 25 and 26, a threshold value of the current value is preset by measuring the current values outputted from each of the piezoelectric elements 24, 25 and 26 several times and subjecting the measured current values to simulation, at which a polishing failure on polishing a semiconductor wafer W, including a jump or a breakdown, is caused to occur. Alternatively, each of waveform patterns W1, W2 and W3 of a periodical variation in the current values outputted from the piezoelectric elements 24, 25 and 26, respectively, are determined by several simulations, at which a failure on polishing is caused to occur, for instance, due to an event of jumping or breaking of the semiconductor wafer W.

[0064]

During the polishing process of the semiconductor

wafer W, the current value of each of the piezoelectric elements 24, 25 and 26 are continually monitored. In the event, for instance, where a semiconductor wafer W breaks or jumps outside from the top ring 4, the current values outputted from the piezoelectric elements 24, 25 and 26 vary due to strong abutment of the semiconductor wafer W with each of the piezoelectric elements 24, 25 and 26 or for other reasons. The measured values are then compared with the threshold values by a control unit (not shown), and an occurrence of a polishing failure on polishing the semiconductor wafer W is determined in the event where either one of the values measured by the piezoelectric elements 24, 25 and 26 exceeds the threshold value. Alternatively, an occurrence of a failure on polishing such as a jump or a breakdown of the semiconductor wafer W is determined as either one of waveform patterns of a periodical variation in the current values measured in a predetermined sampling time agrees with the pre-stored waveform pattern W1, W2 or W3. In the event where it is determined that a failure on polishing occurs, then the driving of the turntable 2 and the top ring 4 is suspended in substantially the same manner as in the first embodiment.

[0065]

In this embodiment, a polishing failure caused, for example, by jumping or breaking of the semiconductor wafer W is detected outside a wafer holding section of the top ring 4, the bottom surface of the guide ring 4-1, and the

top ring 4. Alternatively, it may be detected at either one or two of the locations as described above.

[0066]

[SIXTH EMBODIMENT] … Detection of a failure based on a variation in electric current for driving a motor

Fig. 10 is a schematic front view of a polishing apparatus composed of the polishing table (turntable) 2 and the top ring 4 for use in this embodiment. The same or similar parts and elements are provided with the same reference numerals and symbols as those of the first embodiment, and a description of those parts and elements will be omitted from the following explanation.

[0067]

The polishing apparatus according to this embodiment comprises the polishing tool 1, the turntable 2, the top ring 4, and a rotary arm 6. A semiconductor wafer W held by the top ring 4 is pressed against the polishing tool 1 at a predetermined pressing pressure with a lifting/pressing mechanism (for lowering or lifting the top ring 4 in the directions as indicted by the arrow Z) (not shown) provided in the rotary arm 6. While the wafer W is pressed against the polishing tool 1, the turntable 2 is rotated constantly at a predetermined number of rotations. The number of rotations of the top ring 4 is detected by a measuring device 32-2 for measuring the number of rotations of the top ring 4. A current for driving the rotation of the top ring 4 is controlled by a motor driver 32-1 for rotating the top ring 4 so as to

drive the top ring 4 at a predetermined number of rotations and sent to a rotation drive motor 30 for rotating the top ring 4. Then, the polishing is carried out by rotating the top ring 4 at a predetermined number of rotations while feeding a polishing or grinding material (slurry) S.

[0068]

As a failure on polishing a semiconductor wafer W occurs, for instance, due to a jump or breakdown, resistance to polishing with the polishing tool 1 varies and is proportional to the current value for driving the rotation drive motor 30. Therefore, a failure upon polishing the semiconductor wafer W can be detected by measuring the driving current value. A simulation is carried out several times in the event where a polishing failure occurs, for example, where the semiconductor wafer W jumps or breaks, and a threshold value of a current or a waveform pattern W of a periodical variation in the current value is obtained in advance.

[0069]

During the polishing process of the semiconductor wafer W, a current for driving the rotation of the top ring 4 is continually monitored by a measuring device 32-3 for measuring the current for driving the rotation of the top ring. The monitored current value is then compared with the threshold value by means of a failure detection section 32-4 for detecting a jump or failure of the wafer W. When the monitored current value exceeds the threshold

value as a result of comparison, it is then determined that a polishing failure of the semiconductor wafer W such as jumping or breaking of the wafer W occurs. Alternatively, it is determined that a polishing failure occurs when it is found that a waveform pattern of a variation in the current value measured in a predetermined sampling time agrees with the waveform pattern W as described above. In each case, the driving of the turntable 2 and the top ring 4 is suspended in substantially the same manner as in the first embodiment.

[0070]

In this embodiment, an occurrence of a failure on polishing, including jumping or breaking of the semiconductor wafer W, may be detected in substantially the same manner as described above by measuring a current for driving the rotation of the turntable 2. Alternatively, a change of the current values may be detected by simultaneously measuring the current values of the turntable 2 and the top ring 4. In this case, the driving of the polishing apparatus is suspended when either one of the current values of the turntable 2 and the top ring 4 is changed.

[0071]

[SEVENTH EMBODIMENT] … Detection of a failure by a vibration sensor

Fig. 11 is a schematic front view of the polishing table (turntable) 2 and the top ring 4 for use with the polishing apparatus in this embodiment. The same or

similar parts and elements are provided with the same reference numerals and symbols as those of the first embodiment, and a description of those parts and elements will be omitted from the following specification.

[0072]

For the polishing apparatus in this embodiment, the top ring 4 is provided with a vibration sensor 33, and a polishing failure, such as a jump or other abnormal events of the semiconductor wafer W, is detected on the basis of the signals measured continually by the vibration sensor 33 during the polishing process. The signals indicative of vibration detected by the vibration sensor 33 equipped in the top ring 4 are transmitted to an amplifier 34-1 in a wireless way. Further, a band pass filter 34-2 is provided so as to extract a frequency component required for the detection of the signals indicative of the polishing failure exclusively from the vibration signals amplified by the amplifier 34-1. A vibration analyzer 34-3 is provided so as to analyze the vibration of the signals outputted from the band pass filter 34-2. The signals analyzed are inputted into a failure detection section 34-4 that detects the failure on polishing the semiconductor wafer W and generates a signal for suspending the polishing process in the event where the polishing failure is detected. The suspension signal generated by the failure detection section 34-4 is then transmitted to a drive control unit 34-5 for controlling the drive of the polishing apparatus.

[0073]

A threshold value is preset in the failure detector 34-4, and it is determined that a failure on polishing the semiconductor wafer W occurs when the signal analyzed and outputted by the vibration analyzer 34-3 exceeds the threshold value. Once it is determined that the failure on polishing occurs, then the suspension signal is outputted to the drive control unit 34-5 to suspend the driving of the turntable 2 and the top ring 4 in substantially the same manner as in the first embodiment.

[0074]

In this embodiment, the vibration sensor 33 is used. A distortion sensor or a pressure sensor may be used in place of the vibration sensor. Moreover, a plurality of sensors of an equal type or of a different type may be used, and they may be disposed such that the operation of the polishing apparatus is caused to be suspended in the event where either one of the sensors detects a failure on polishing.

[0075]

[EIGHTH EMBODIMENT] … Detection of a failure by a displacement sensor

Fig. 12 is a schematic front view of the polishing table (turntable) 2 and the top ring 4 for use with the polishing apparatus according to the present invention. The same or similar parts and elements are provided with the same reference numerals and symbols as those of the first embodiment, and a description of those parts and

elements will be omitted from the following explanation.

[0076]

For the polishing apparatus in this embodiment, a displacement sensor 35 of a non-contact type is disposed over the top ring 4 so as to measure a variation in position of the top surface of the top ring 4. The variation in the position of the top surface of the top ring 4 is continually measured by the displacement sensor 35 during the polishing process in order to detect a failure on polishing a semiconductor wafer W. In this embodiment, a displacement sensor of a contact type may also be used in place of the displacement sensor 35. In this embodiment, a signal outputted from the displacement sensor 35 of a non-contact type is transmitted to a displacement measuring section 35-1 that translates the input signal to a displacement amount. A failure detection section 35-2 detects a failure on polishing, including a jump or breakdown of a semiconductor wafer W, and outputs a suspension signal to a drive control unit 35-3.

[0077]

For a comparison with the measured displacement value, a threshold value is preset in the failure detection section 35-2, and it is determined that a failure on polishing a semiconductor wafer W occurs, such as a jump or breakdown of the wafer W, in the event where the displacement amount outputted from the displacement measuring section 35-1 exceeds the threshold value. Once

the failure on polishing would be detected, a suspension signal is transmitted to the drive control unit 35-3 to suspend the turntable 2 and the top ring 4 in substantially the same manner as described above.

Reference numeral 5-1 denotes a spherical bearing, and reference numerals 5-2 and 5-3 denotes each a torque transmission pin.

[0078]

[Effects of the Invention]

The polishing apparatus according to the present invention is provided with a detection system for detecting a failure on polishing a polishing substrate, including a jump or breakdown of a polishing substrate, so that a failure on polishing the polishing substrate can be detected accurately during the polishing process. Therefore, once the polishing failure would be detected, the operation for polishing the polishing substrate can be immediately suspended to prevent the polishing substrate itself or devices or parts constituting a guide ring, an abrasive cloth, a packing member and a dressing member from being damaged by a jump of the substrate from the top ring.

[Brief Description of the Drawings]

[Fig. 1]

A schematic front view showing an essential portion of a polishing table (turntable) 2 and a top ring 4 disposed in a polishing apparatus 110.

[Fig. 2]

A schematic side view showing the essential portion of the polishing table 2 and the top ring 4, when viewed from the arrow A indicated in Fig. 1.

[Fig. 3]

A schematic control block diagram for a supersonic sensor 10.

[Fig. 4]

A schematic flow diagram showing as an example a method of detecting a failure on polishing a semiconductor wafer W during the polishing process with the supersonic sensor 10.

[Fig. 5]

A schematic front view showing an essential portion of the polishing table (turntable) 2 and the top ring 4 for use in the present invention.

[Fig. 6]

A schematic control block diagram for supersonic sensors 10-1 and 10-2.

[Fig. 7]

A schematic front view showing a essential portion of the polishing table (turntable) 2 and the top ring 4 for use in the present invention.

[Fig. 8]

A view showing the polishing table (turntable) 2 and the top ring 4 for use in the present invention, in which Fig. 8(a) is a schematic plan view showing the essential portion thereof; and Fig. 8(b) is a schematic front view showing the essential portion thereof.

[Fig. 9]

A view showing the polishing table (turntable) 2 and the top ring 4 for use in the present invention, in which Fig. 9(a) is a schematic plan view; and Fig. 9(b) is a schematic front view.

[Fig. 10]

A schematic front view showing an essential portion of the polishing table (turntable) 2 and the top ring 4 for use in the present invention.

[Fig. 11]

A schematic front view showing the polishing table (turntable) 2 and the top ring 4 for use in the present invention.

[Fig. 12]

A schematic front view showing the polishing table (turntable) 2 and the top ring 4 for use in the present invention.

[Fig. 13]

A schematic view showing an entire outline of an example of the polishing apparatus with a cleansing device.

[Explanation of Reference Marks]

110 (110a, 110b): polishing machine,

1: polishing tool,

2: polishing table (turntable),

3: rotary table shaft,

4: top ring,

5: rotary top-ring shaft,

6: turn arm of top ring,

7: rotary turn-arm shaft,

S: grinding fluid (slurry),

50: grinding fluid supply tube,

51: arm,

10: supersonic sensor (failure detection sensor),

10a: supersonic wave transmitting section,

10b: supersonic wave receiving section,

43: control unit,

45: motor control section for controlling a motor driving turntable,

46: motor control section for controlling a motor driving top ring,

W: semiconductor wafer (polishing substrate),

10-1, 10-2: supersonic sensors (failure detection sensors),

4-1: guide ring,

4-4, 4-5: passages,

11-1, 12-1: circular negative-electrode plates,

11-2, 12-2: ring-shaped positive-electrode plates,

4-6: backing member,

17: support bar,

E: voltage source,

A1, A2: ammeters,

16-1, 16-2: slip rings,

20: ring-shaped conductive member,

21: ring-shaped contact member,

22-1: conductive contact member,

22-2: conductive contact member,

23-1: conductive member,

23-2: conductive member,

A1, A2, A3: ammeters,

24, 25, 26-1, 26-2: piezoelectric elements,

27-1, 27-2: supports,

28: spacer,

30: rotation drive motor,

32-1: motor driver for rotating top ring,

32-2: measuring device for measuring a number of rotations of top ring,

32-3: measuring device for measuring a current for driving rotation of top ring,

32-4: wafer jump and disorder detection section,

33: vibration sensor,

34-1: amplifier,

34-2: band pass filter,

34-3: vibration analyzer,

34-4: wafer jump and disorder detection section,

34-5: drive control unit for controlling drive of the polishing apparatus,

35: displacement sensor of a non-contact type,

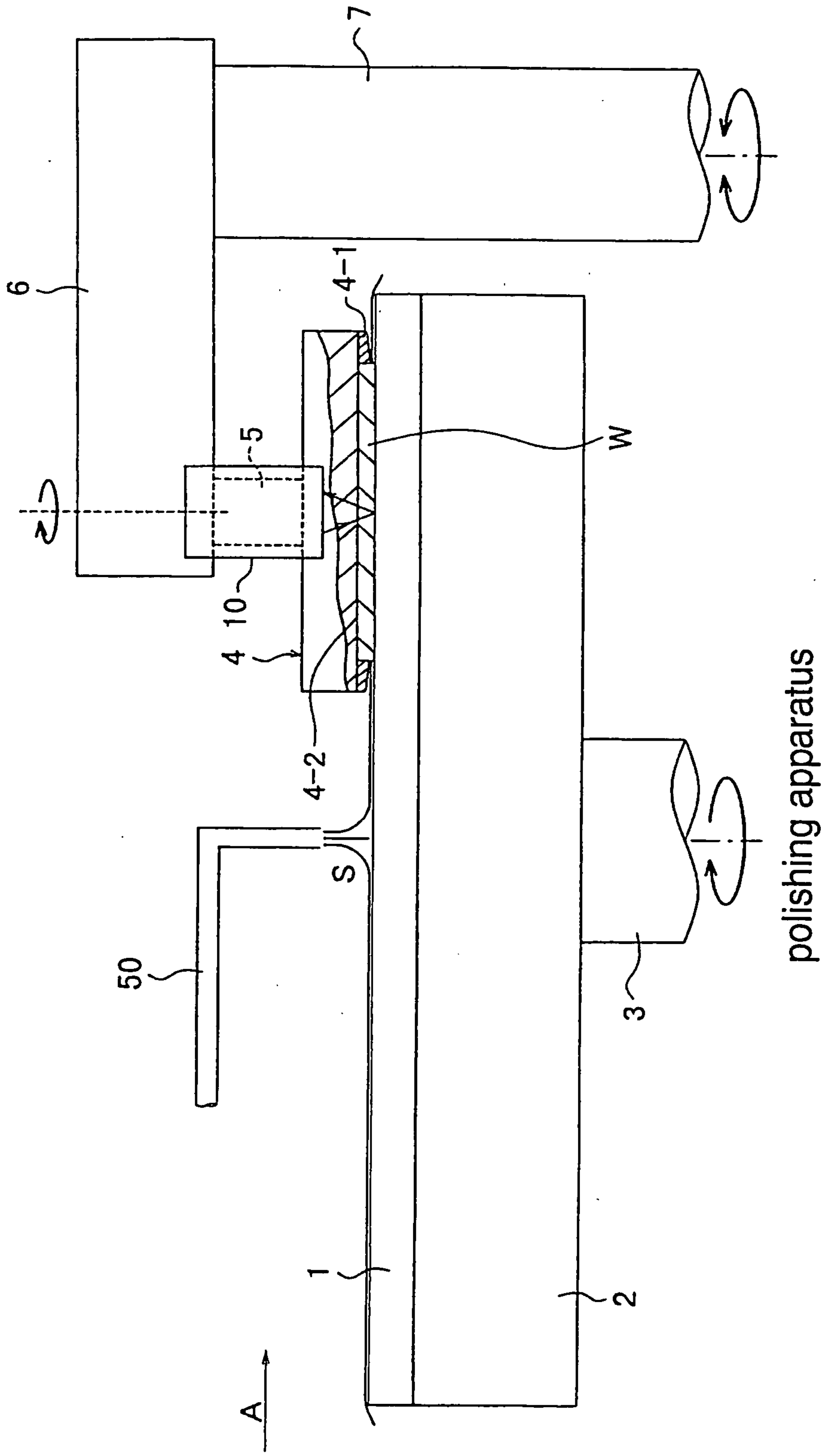
35-1: displacement measuring section,

35-2: wafer jump and disorder detection section,

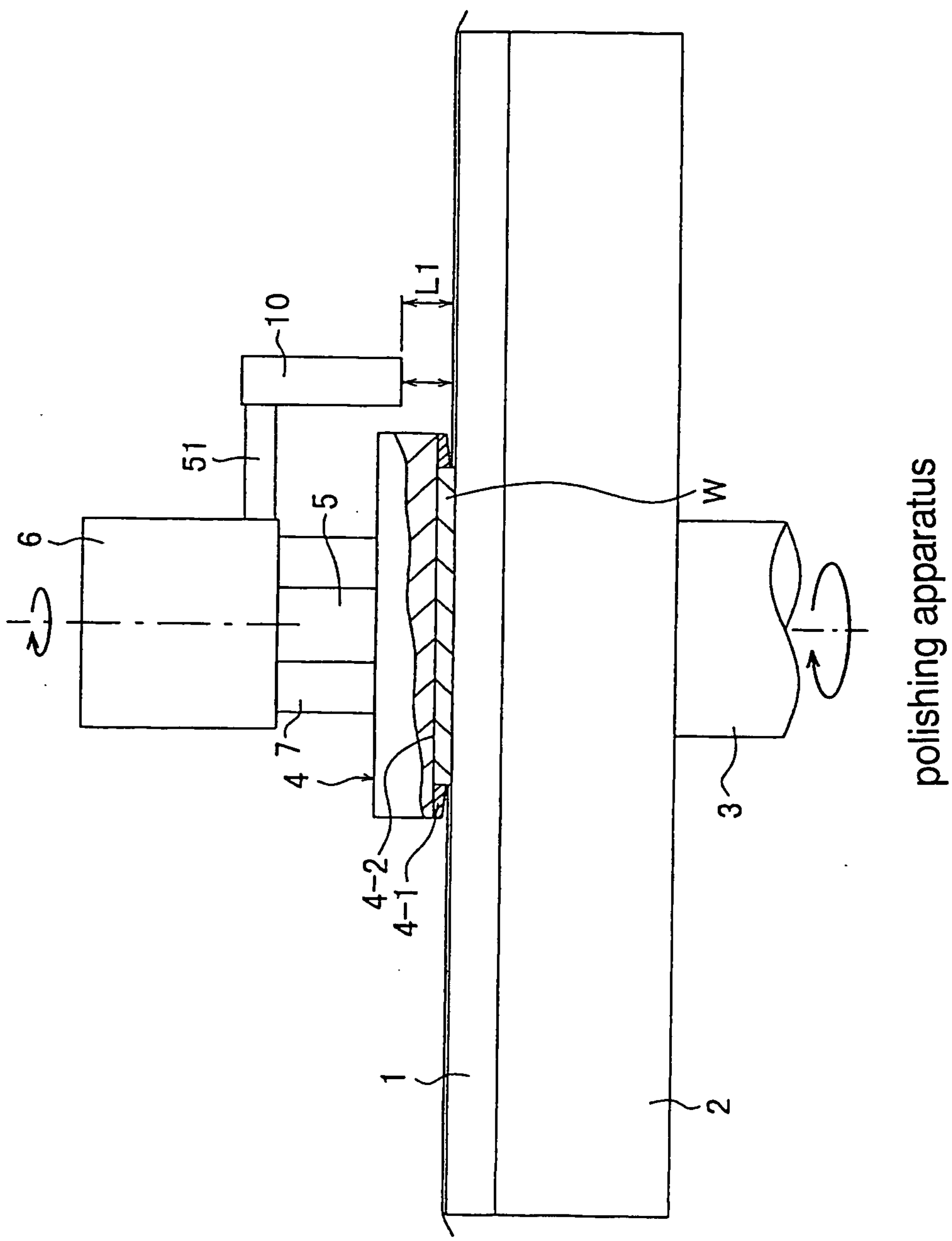
35-3: drive control unit for controlling drive of the polishing apparatus.

[Name of Document] Drawings

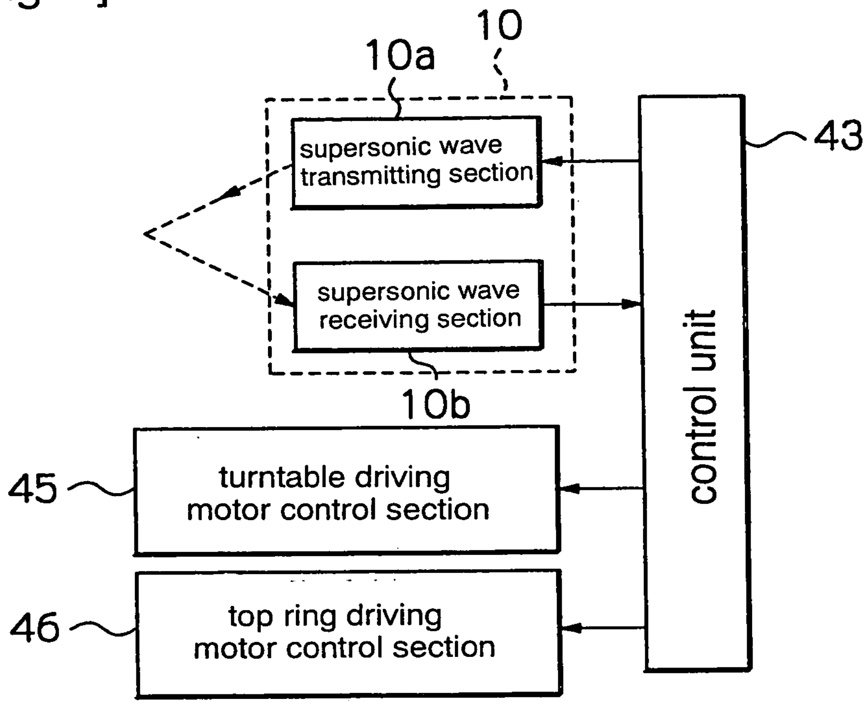
[Fig. 1]



[Fig. 2]

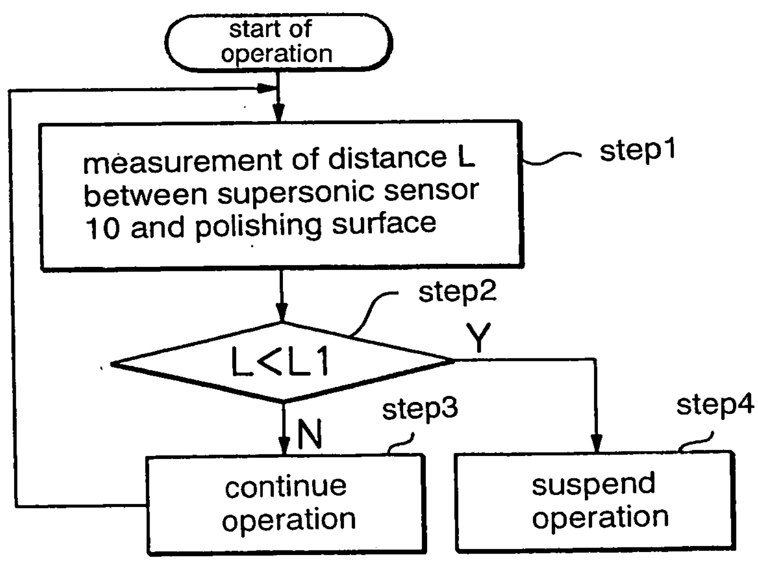


[Fig. 3]



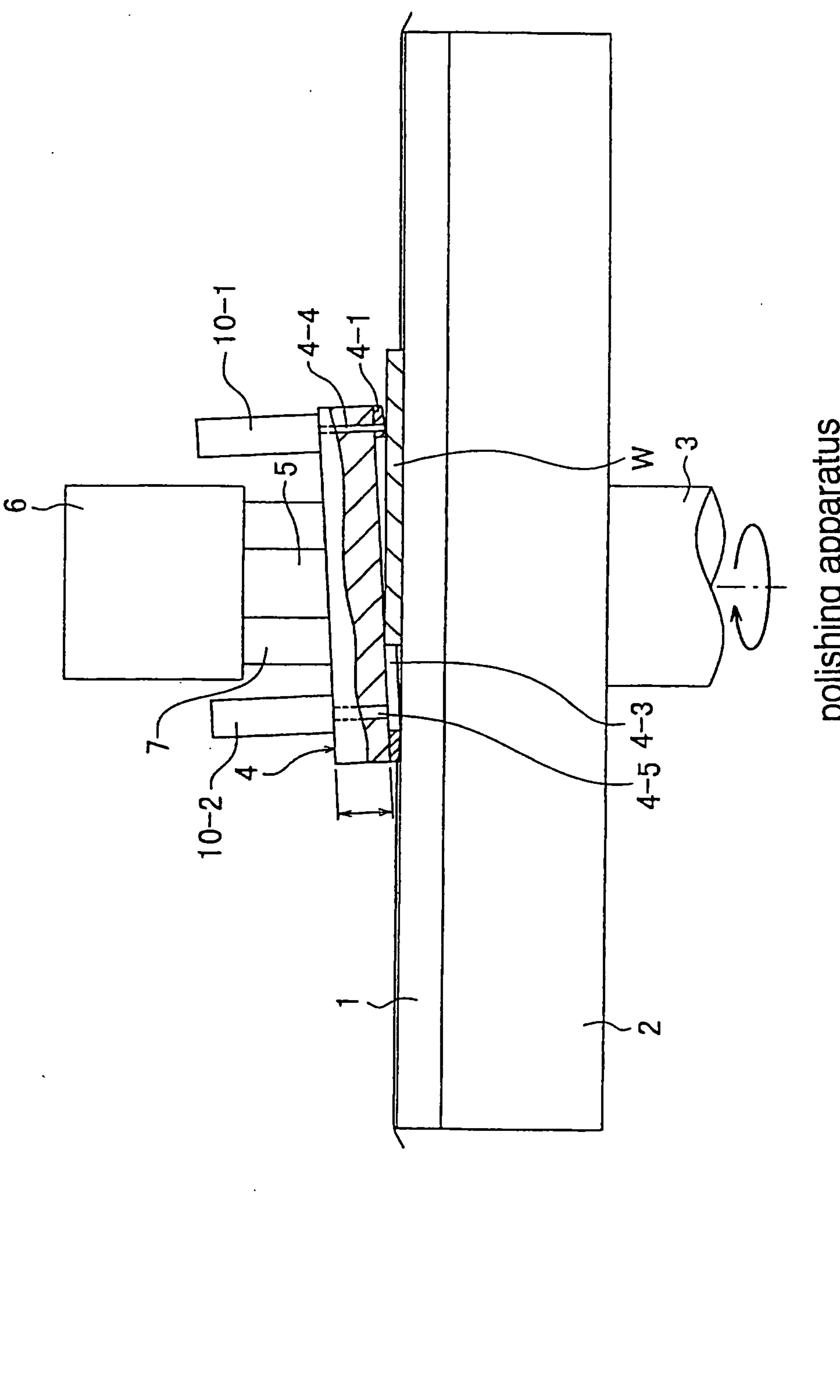
schematic control block diagram

[Fig. 4]

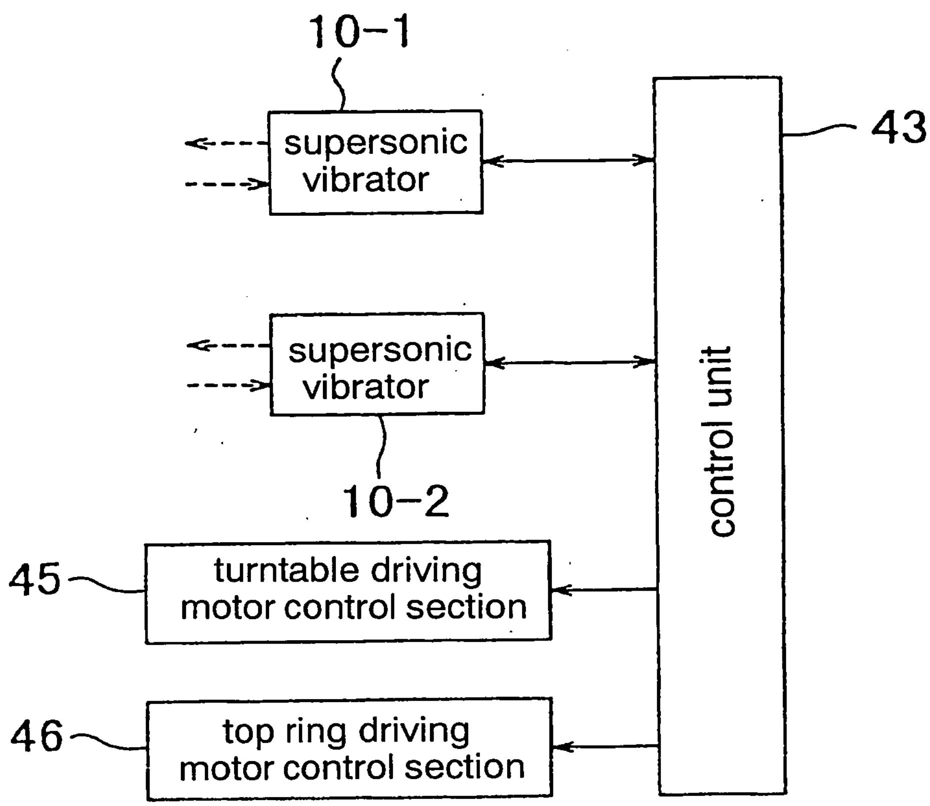


control flow diagram for
detection of failure on polishing

[Fig. 5]

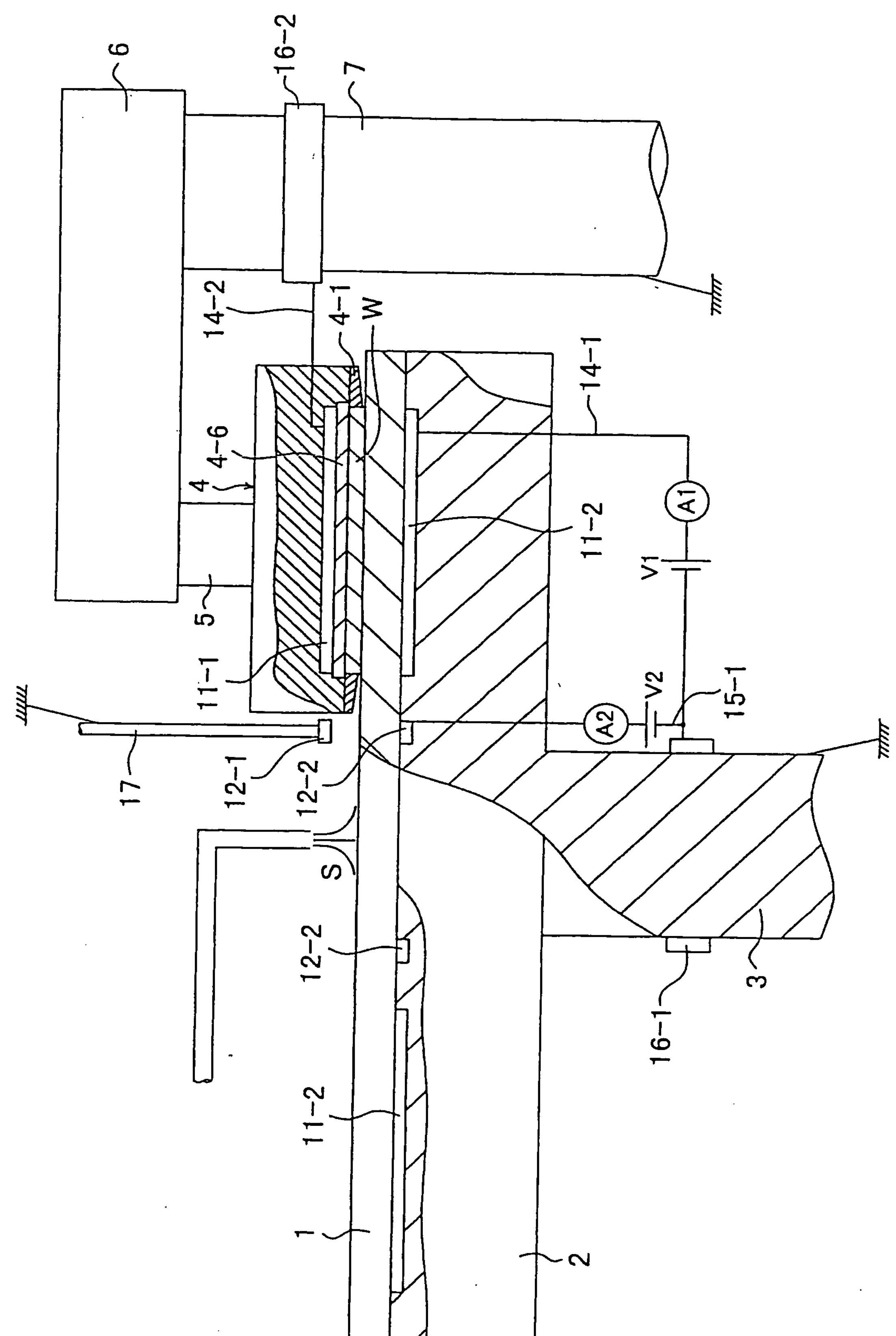


[Fig. 6]



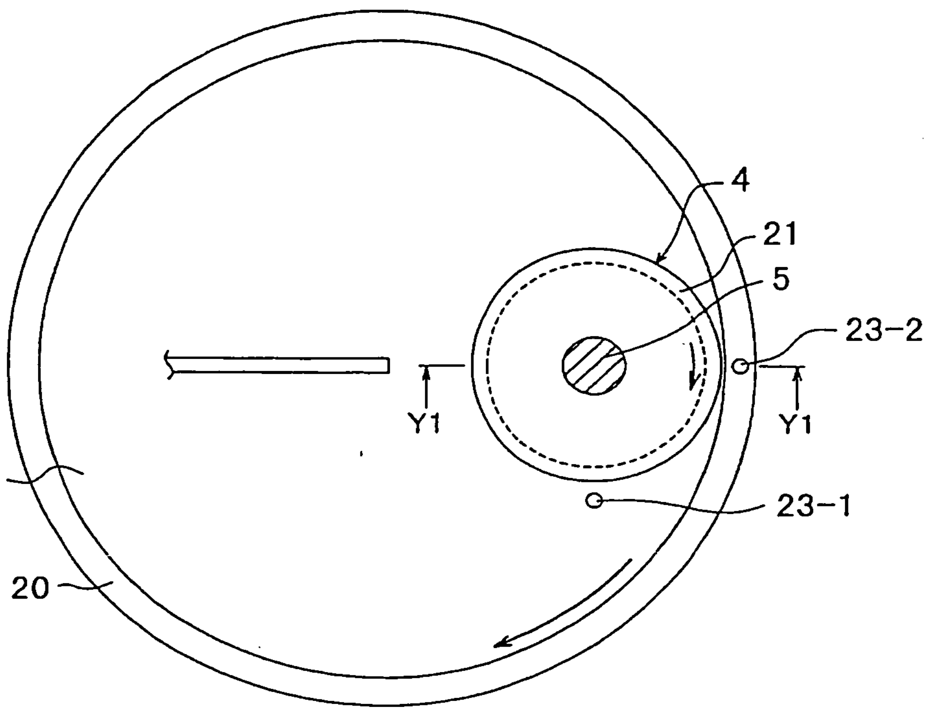
schematic control block diagram

[Fig. 7]

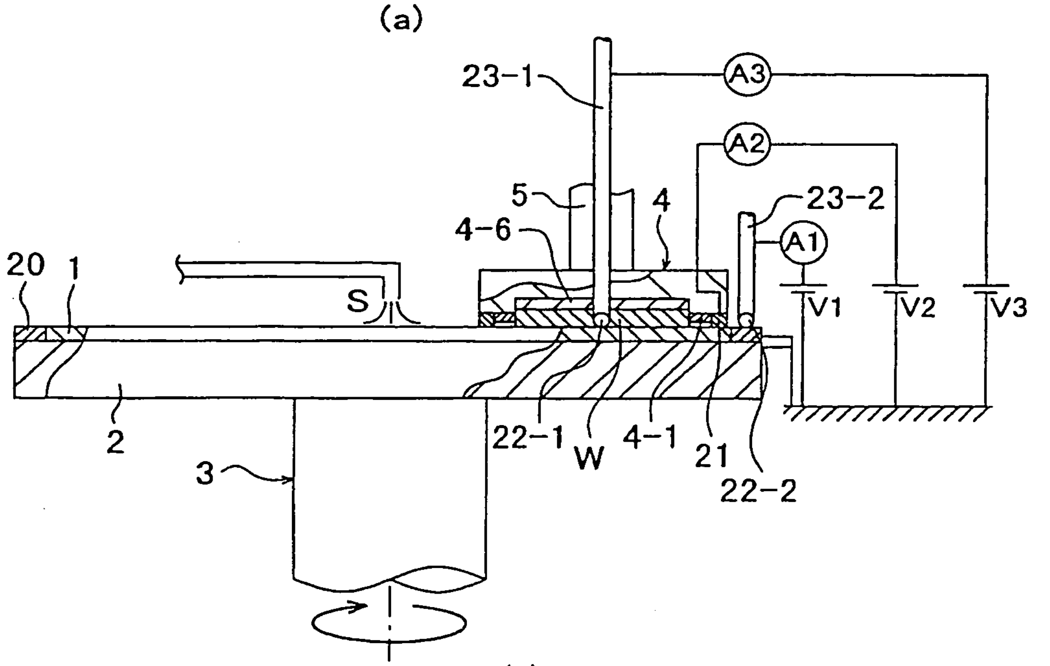


polishing apparatus

[Fig. 8]



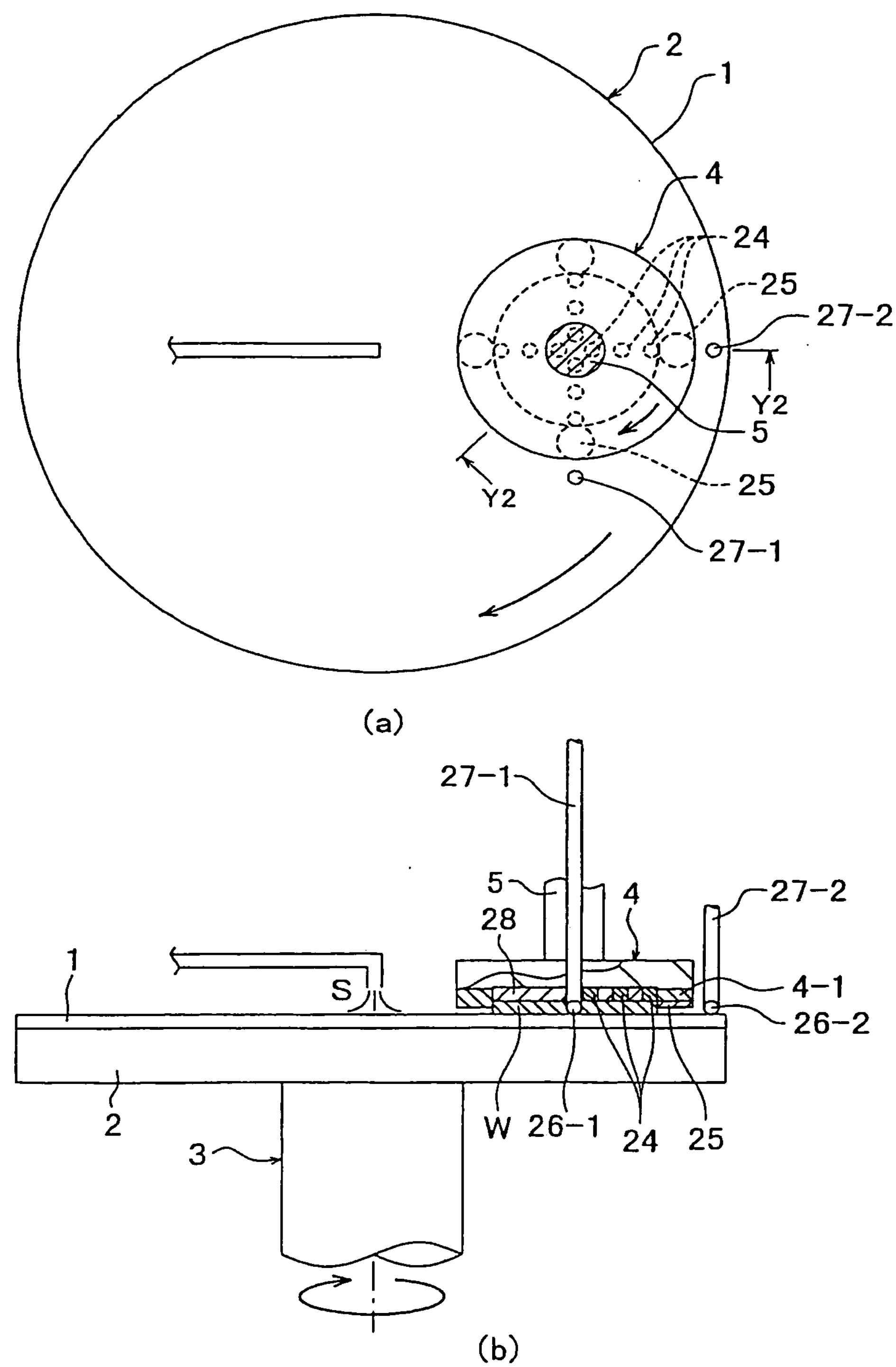
(a)



(b)

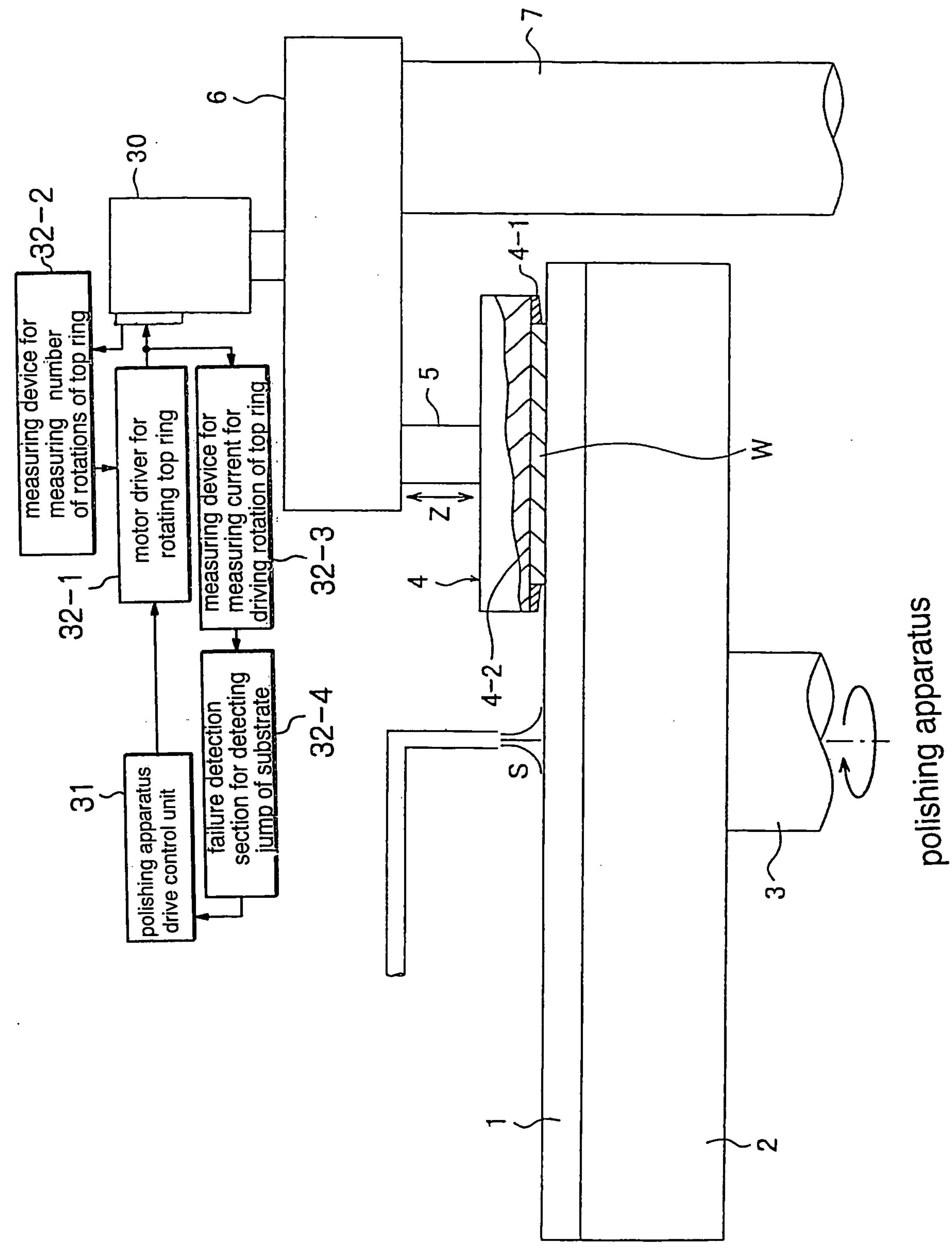
polishing apparatus

[Fig. 9]



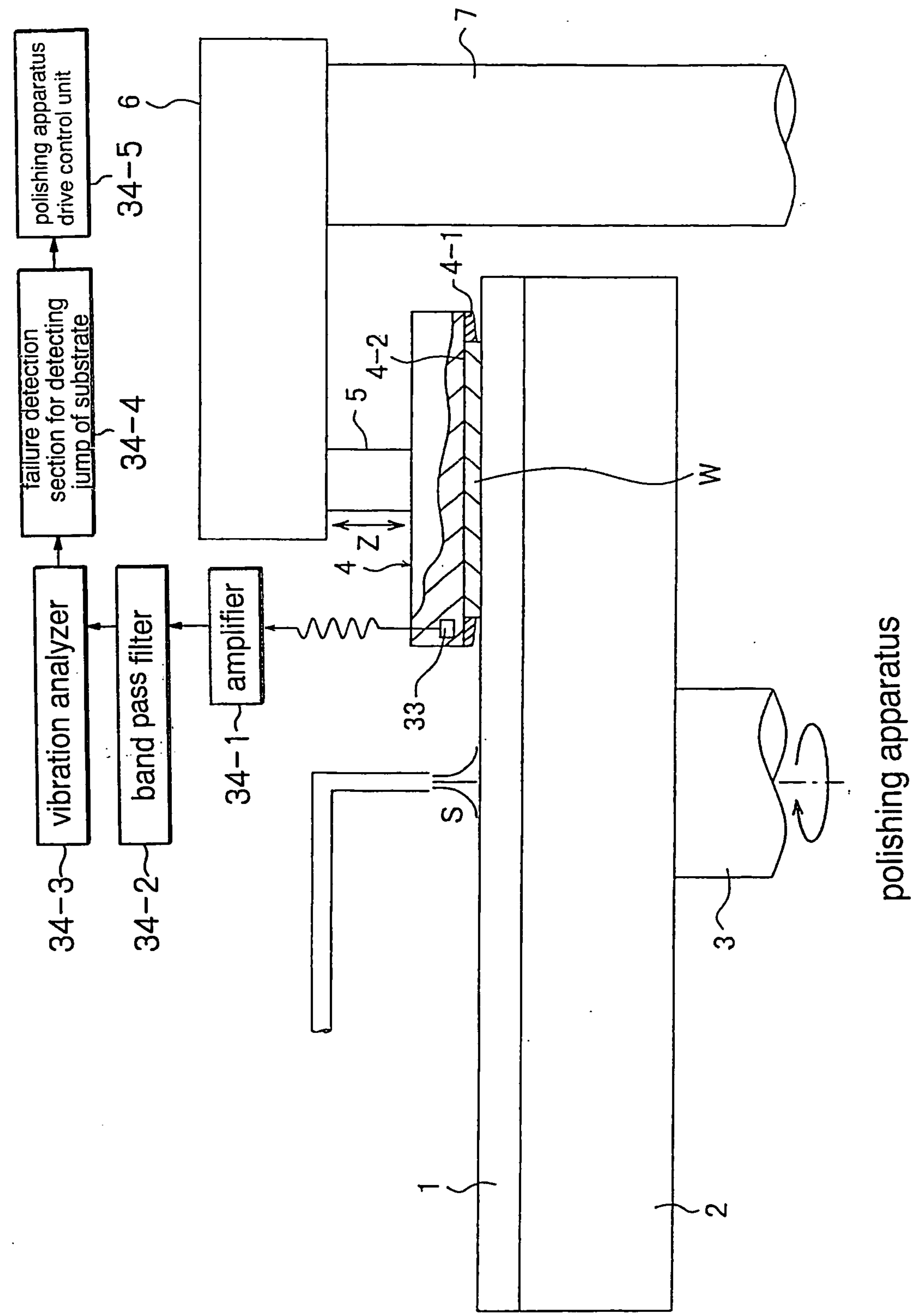
polishing apparatus

[Fig. 10]



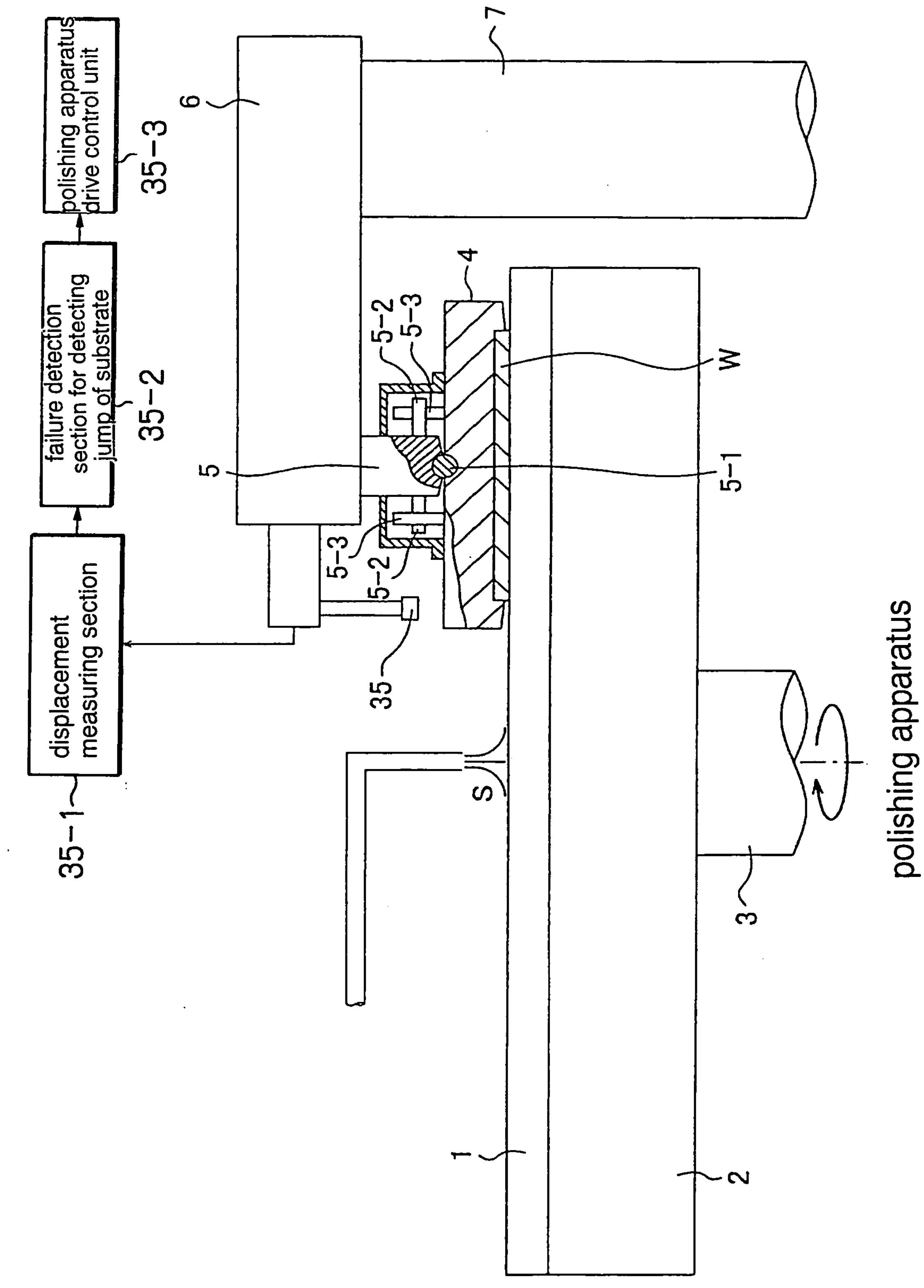
7
6
30
32-2
measuring device for measuring number of rotations of top ring
motor driver for rotating top ring
32-1
measuring device for measuring current for driving rotation of top ring
32-3
failure detection section for detecting jump of substrate
32-4
polishing apparatus drive control unit
31
4-1
5
W
Z
4
4-2
S
3
1
2
polishing apparatus

[Fig. 11]



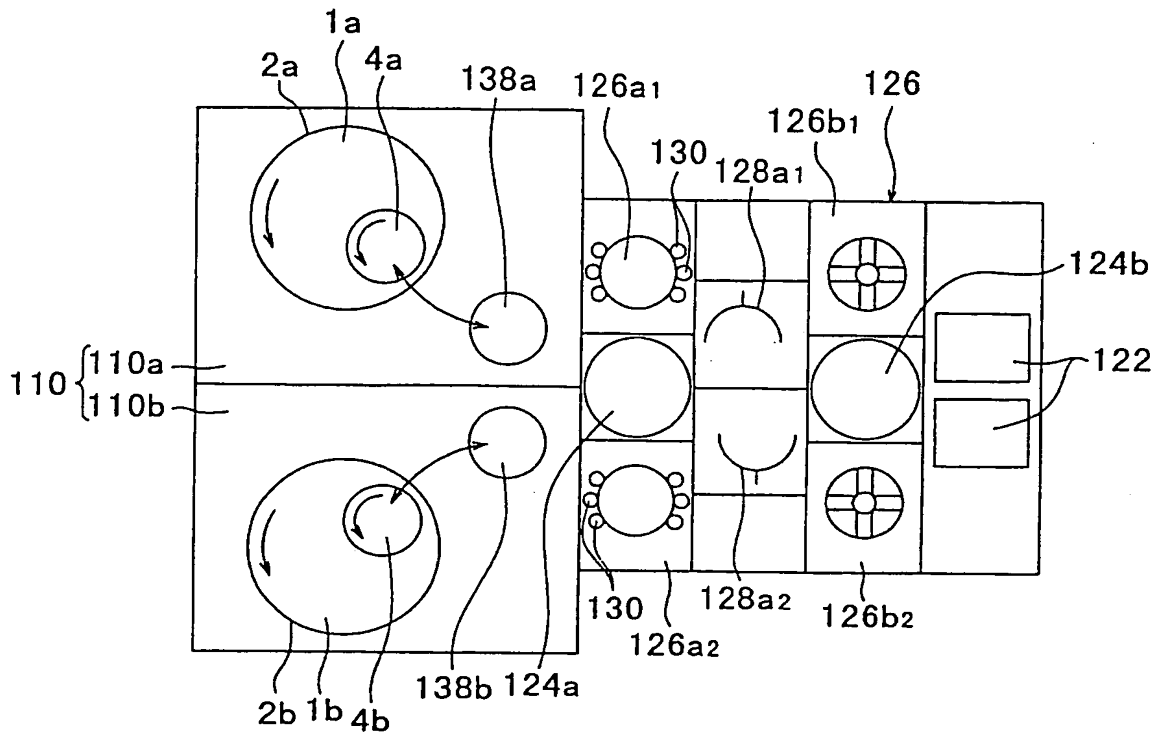
polishing apparatus drive control unit
34−5
6
7
failure detection section for detecting jump of substrate
34−4
4−1
4−2
5
W
Z
4
vibration analyzer
band pass filter
amplifier
33
34−1
34−3
34−2
S
3
polishing apparatus
1
2

[Fig. 12]



displacement measuring section
failure detection section for detecting jump of substrate
polishing apparatus drive control unit
35-1
35-2
35-3
6
7
5
4
5-2
5-3
W
5-1
35
S
1
2
3
polishing apparatus

[Fig. 13]



schematic view of entire outline of polishing apparatus with cleansing device

[Name of Document] Abstract

[Abstract]

[Problem] To provide a polishing apparatus that can prevent an occurrence of damages due to a failure on polishing, including a breakdown or a jump of a polishing substrate, by continually managing the polishing operations of the polishing substrate during the polishing process.

[Means for Solving] A polishing apparatus including a polishing tool 1 and a substrate holding member 4 to hold a polishing substrate W and press a polishing surface of the polishing substrate W against a grinding surface of the polishing tool 1. The polishing tool 1 and the substrate holding member 4 move relative to each other to polish the polishing substrate W. A sensor 10 is disposed outside the substrate holding member 4 to sense a distance between the sensor 10 and the surface of the polishing tool 1. A control unit is disposed to determine an occurrence of a polishing failure of the polishing substrate, including a jump thereof from the substrate holding member, when a variation in the distance to the surface of the polishing tool 1 measured by the sensor 10 is detected.

[Selected Drawing] Fig. 1